

History of
**U. S. NAVAL
RADIOLOGICAL
DEFENSE
LABORATORY**

**for the
year**

1964

This document is designed to serve the dual purpose of
Command History and Annual Administrative Report

S A N F R A N C I S C O C A L I F O R N I A

347

TABLE OF CONTENTS

<u>Chapter</u>		<u>Page</u>
I	GLOBAL MANEUVERS.....	1
	The Year of Contracts.....	1
	Cyclotron Management Change - Construction Progress	1
	NRDL Role in SNPO Programming.....	3
	Scientific Director to London.....	3
	Scientific Program Reviews Initiated.....	4
	BUSHIPS Inspection Team in July.....	4
	BUSHIPS Program Review.....	4
	Dr. Robert Reid Newell Retires.....	5
	Major Personnel Changes.....	6
	Organizational Changes.....	7
	Organization Chart.....	9
	Major Facilities.....	10
II	TECHNICAL PROGRESS AND ACCOMPLISHMENTS	
	Protection Against Nuclear Weapons	
	and Radiation, Radiation Measurement.....	13
	Oceanographic, Radio-Chemistry, Fallout Studies...	21
	Biological Research.....	26
	Other Research Program Developments.....	34
III	PUBLICATIONS.....	35
IV	AWARDS -- COMMENDATIONS -- HONORS.....	37
V	SEMINARS -- SYMPOSIA -- CONFERENCES.....	45
VI	TRAINING.....	48
VII	VISITORS.....	49
VIII	PUBLICITY.....	52
IX	MISCELLANEOUS.....	53

PHOTOGRAPHS

<u>Subject</u>	<u>Page</u>
70" Magnet for Cyclotron.....	2
Dr. Robert Reid Newell.....	5
Mobile Spectrometer Completed.....	12
3rd Gold Medal Winner -- Dr. Marvin Lee Tyan.....	39
Silver Medal Winner -- Dr. William C. Schieve.....	39
Superior Civilian Award -- Albert L. Smith.....	39
Scientists-in-Residence -- Dr. John Davidson; Åke A. Svanheden; Raymond Schofield.....	42
Eminent Guests -- Assistant Secretary of the Navy (R&D) Dr. R. W. Morse.....	51
12ND Commandant -- RADM John Taylor.....	51

CHAPTER I -- GLOBAL MANEUVERS

Field studies during 1964 took NRDL scientists to Costa Rica to study ash and sand fallout and its effects resulting from eruptions from the volcano Irazu; to Alaska following the 27 March earthquake to study different aspects of damage to structures, pertinent to Target Vulnerability Studies; on a water sampling oceanographic expedition investigating the global radioactive fallout inventory in the North Pacific Ocean; on flights of aerial reconnaissance of high explosive and underground nuclear explosions, including Suffield, Canada, Hattiesburg, Miss., and the Nevada Test Site.

CONTRACTS MANAGEMENT, MONITORING ADDED

NRDL efforts took a new turn in 1964 toward the role of management and technical advisory service on research contracts to private industry research organizations. This new task, undertaken in addition to an increased in-house research program, was to total some \$3,500,000 for FY65.

Most prominent of the contractual responsibilities was the program of research management resulting from an agreement between the Office of Civil Defense and the Bureau of Ships, in which OCD requested program review by NRDL of 41 contracts. A Technical Management Office was set up at NRDL, principally for the OCD projects and headed by Mr. P. E. Zigman.

CYCLOTRON MANAGEMENT CHANGE - CONSTRUCTION PROGRESS

During November some organizational changes were instituted to strengthen management of the cyclotron effort. It was announced that Dr. H. A. Howe would devote full time to design, with Dr. W. E. Kreger, Head, Nucleonics Division, assuming collateral duties as Head, Accelerator Branch. Dr. Kreger is also supervising the overall scheduling of design and construction.



70" MAGNET FOR CYCLOTRON, shown above, is in final stages of assembly with main section and yoke completed. Magnet coils are in place around the main magnet pole pieces. Top surface of the gunmount is in foreground.

Installation of the main magnet core and coils was completed at the end of the year. The centerline of the main magnet was carefully located to coincide with the centerline of the gun mount support, thus allowing both the magnet and the support to rotate both concentrically rather than excentrically. Boston Naval Shipyard proceeded with the fabrication of the holsters and heel seams which will be used to control the magnet field. Ling Electronics delivered the completed main magnet power supply. Installation and hook-up followed in December. Preliminary testing of the magnet was scheduled for January 1965.

NRDL ROLE IN SNPO PROGRAMMING

By a formal agreement arranged between the Bureau of Ships and the AEC late in the year, NRDL was assigned technical management responsibility for the SNP Office's Space Nuclear Propulsion Radiological Effects Program. The SNP Office has the national responsibility for the development of nuclear engines for propulsion in space. There was a meeting at NRDL for SNPO contractors who will participate in the program formulated by NRDL. Agreement was obtained on total program obligations, intentions and conduct. Research assignments were affected and tentative task completion dates established. Follow-on coordination conferences were scheduled to complete the program assignments and to precisely define the nature of interface research items and to fix all completion dates.

SCIENTIFIC DIRECTOR TO LONDON

Dr. Eugene P. Cooper, Scientific Director, temporarily moved his office to the ONR Branch Office in London for a year starting in July. This temporary arrangement, proposed by the Laboratory and supported by BUSHIPS and ONR, is for the mutual benefit of all three organizations. Although Dr. Cooper continued as NRDL Scientific Director, the main day-to-day burden of scientific directorship was borne by Associate Scientific Director, Dr. Edward R. Tompkins. Dr. Cooper kept in touch with developments at NRDL, particularly with critical program matters. While NRDL had had a number of emissaries visiting Europe and had had many contacts in specific scientific areas, the Scientific Director had not previously been directly involved. Dr. Cooper's assignment will provide a broad programmatic liaison with significant efforts in Europe related to the NRDL program; for instance, the important research area associated with AVF cyclotrons. When Dr. Cooper returns, the NRDL cyclotron should be partially complete and it will be important for him to have a good background in connection with these types of machines which have been primarily developed in Europe. The arrangement also gives Dr. Cooper extensive liaison with research centers in Western Europe and a broadened

perspective on the NRDL mission in relation to worldwide developments in radiological science.

SCIENTIFIC PROGRAM REVIEWS INITIATED

In September, a weekly program review before a Program Review Board, including the Commanding Officer and Director, the Associate Scientific Director, scientific Division Heads and selected Branch Heads, was inaugurated. Purpose of the review, which has proven to be extremely effective in improving communication and planning across Division lines, is to further induce each Branch Head to plan his program as carefully as possible in anticipation of critical review about twice a year. It also tends to spotlight commitments, makes all senior people more aware of the details of the Laboratory program, and leads to better overall program planning and coordination. As the year ended, six of these reviews had been completed.

BUSHIPS INSPECTION TEAM IN JULY

A BUSHIPS management inspection team of 17 members headed by CAPT R. E. Barnhart, USN, conducted a management review at NRDL on 13-15 July. During the departure conference, it was indicated that NRDL, in the opinion of the inspecting party, was excellently run. Formal recommendations drafted by the team pertained to funding processes by other than BUSHIPS' sponsors, excessive reporting requirements found to have been imposed upon the Laboratory, facilities planning, and the designation of NRDL as the lead laboratory for nuclear weapons effects.

BUSHIPS PROGRAM REVIEW

Held in conjunction with the Inspector General's visit, a review of the NRDL Technical Program by a BUSHIPS group on 13-17 July resulted in a final understanding between the Laboratory and the Bureau on the FY-65 Technical Program and program planned for FY-66. BUSHIPS participants included M. R. Hoagland, R. G. Attmore, and R. E. Siefert.

MAJOR PERSONNEL CHANGES

CIVILIAN

CHEMICAL TECHNOLOGY DIVISION

Dr. Richard Cole, who had headed the Countermeasures Evaluations Branch of the Military Evaluations Division for $3\frac{1}{2}$ years, was selected as Head of the Chemical Technology Division, succeeding Dr. Lewis H. Gevantman. Dr. Gevantman went to Vienna, Austria, as Senior Scientific Adviser to the U. S. Mission to the International Atomic Energy Agency.

MILITARY EVALUATIONS DIVISION

Mr. Sam Rainey, Head of the Weapons Capabilities Branch of the Military Evaluations Division since coming to NRDL in 1961, moved up to the Head of the MED Division, replacing Mr. C. F. Ksanda. Mr. Ksanda was chosen to head the newly established Operational Requirements Office (see Organizational Changes, page 8).

MILITARY

KEY OFFICER CHANGES

Among the key officer changes were the following:

LCDR Bayard T. Sansom, USN, relieved CDR Robert J. Connolly, USN, as Technical and Administrative Services Director when he retired. Also retiring were CDR T. L. Birch, USN, Assistant to the Commanding Officer and Director (billet not filled), and CDR Gale L. Bergey, USN, who had been relieved late in 1963 by LCDR Terry Johnson as Camp Parks Representative. These three officers' civilian plans were not certain when they left the Navy. Subsequently, LCDR Johnson retired and went to New Orleans to work for the City Recreation Department. He was relieved by LT Arunis Dirvianskis, USN, and when Dirvianskis was transferred to the USS

Haleakala, the Camp Parks Representative was LCDR Albert G. Opitz, USN, formerly in the Military Evaluations Division.

CDR Frank J. Kilgore, USN, who had occupied two billets, retired and became a student at the University of California. He was relieved as Senior Program Officer by CDR Webster B. Heidt, Jr., USN, formerly at NRDL from 1949-52 as BUSHIPS Project Officer. LCDR E. L. St. Ville, USN, relieved CDR Kilgore as Cyclotron Coordinator.

Major Rice Trolan, CMLC, USA, ARMY liaison officer, transferred to Ft. Leavenworth, Kansas to attend the Army Staff College. Captain Lewis W. Pettit, CMLC, USA, is now the Army liaison officer at NRDL.

EIGHT DISTINGUISHED CONSULTANTS UNDER CONTRACT

Eight distinguished scientists under contract to NRDL for consulting services during the year included Dr. Robley D. Evans, Professor of Physics, Massachusetts Institute of Technology; Dr. Abraham Broide, Chief Scientist, Pacific Southwest Forest and Range Experiment Station, Berkeley; Dr. Maurice Holt, visiting Professor, Aeronautical Sciences, University of California; Dr. Cecil Entenman, Director, Institute for Lipid Research, Berkeley; Dr. Bernard D. Kern, Professor of Physics, University of Kentucky; Dr. Victor J. Rosen, Pathologist, Veterans Hospital, Long Beach; Mr. Virgil C. Schrock, Associate Professor Nuclear Engineering, University of California; and Dr. Harry Heckman, Physicist, Lawrence Radiation Lab., Berkeley.

ORGANIZATIONAL CHANGES

The chart on page 9 shows graphically the organization of NRDL as of 31 December 1964. During the year several significant changes in organization were made:

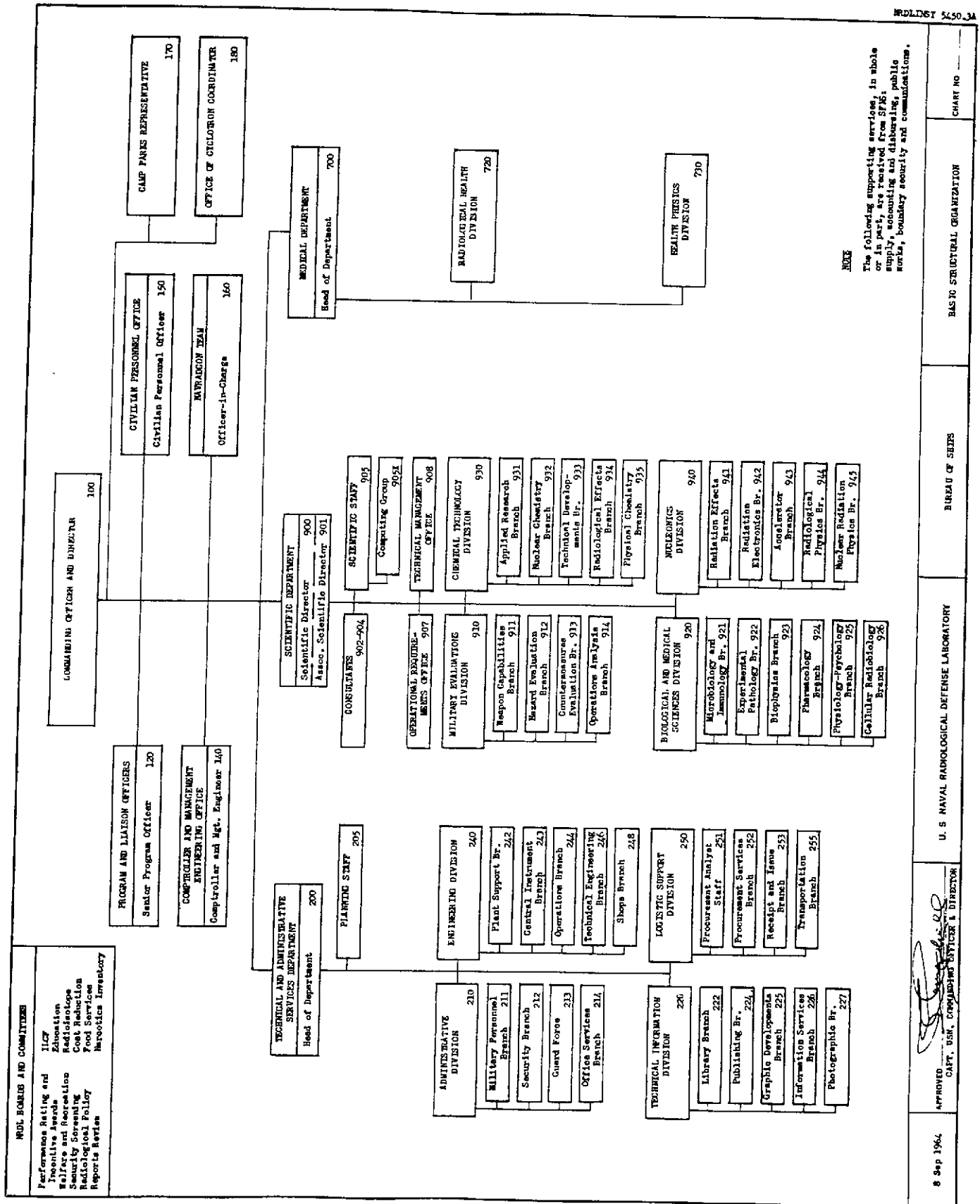
The Administrative and Technical Services Departments were combined in a single department titled the Administrative and Technical Services Department, Code 200. Administrative elements were relocated within the new department as follows -- Administrative Division, Code 210; Military Personnel Branch, Code 211; Security Branch, Code 212; Guard Force, Code 213; and Office Services Branch, Code 214. Functions remain unchanged.

The Computing Branch was moved to the Scientific Department Staff Office (Code 905) and redesignated as the Computing Group, Code 905X.

The Operational Requirements Office, Code 907, was established, reporting directly to the Scientific Director. Its role will be to formulate requirements for information necessary for operations (principally military) in nuclear and interrelated warfare environments.

The Technical Management Office, Code 908, was established, reporting directly to the Scientific Director. Its role will be to provide program and technical guidance for contracted research under agreements with other Federal agencies.

A Cost Reduction Committee and a Cost Reduction Coordinator was established to coordinate NRDL's participation in the DOD-wide Cost Reduction Program. (The Secretary of the Navy commended all hands for helping the Department exceed its 1964 Cost Reduction Program goal...conservative estimate over one billion dollars against goal of 912 million.)



MAJOR FACILITIES

CAMP PARKS CONSOLIDATION

Inasmuch as the Army has been directed to dispose of parts of Camp Parks -- and anticipating the eventual loss of much of the flat land in the main camp area, NRDL started to consolidate holdings to the north (rear) of the main camp. A refurbished office building was occupied in this area. These consolidation plans formed the basis for a request made via DFWO-12 to the Corps of Engineers in Sacramento for permanent title to 1600 acres of land and certain buildings. The personnel in the Technical Developments Branch of the Chem Tech Division were moved to Camp Parks on a permanent duty station basis. This included 25 civilian scientists and technicians and 4 military.

Plans were initiated to acquire an additional 85 acres of grazing land at Camp Parks to accommodate the increased number of animals for studies in the effects of protracted radiation on mammalian systems.

The Department of the Army renewed its permit to the Laboratory to use certain building and ground areas, covering approximately 600 acres at Camp Parks. The new permit covers the five-year period from 1 July 1964 to 30 June 1969.

A Weather Station was started at Camp Parks in an effort to accumulate data which, in the future, can be used to predict the most suitable conditions for outdoor experimental work.

NEW PULSE HEIGHT ANALYZER

A significant addition to the Laboratory's research facilities was an \$111,725 transistorized, multi-parameter pulse height analyzer. Ordered in May 1963, it was delivered to the Laboratory and put into operation in mid-summer. Built by the Technical Measurements Corporation under specifications developed by the Nuclear Chemistry Branch at NRDL, this instrument system represents a major addition to NRDL capabilities for nuclear research. It provides a means of obtaining previously unobtainable data contained in the pulse amplitude and in the pulse time relationships of nuclear decay events. The advantages of this equipment over previous instruments are the greatly improved precision, facility and speed of operation made possible by its large storage capacity. This capacity makes it possible to study samples having short half lives or samples in which complex decay processes result in rapidly changing radiation characteristics, e.g., early time decay following fission and parent-daughter radioactivity growth of species having short half lives.

COMPLETE 704 COMPUTER SYSTEM INSTALLED

In July, a complete IBM 704 Computer System with a 32-K memory was obtained from General Dynamics for only \$100,000. The new computer installation was needed due to the increasing inadequacies of the former Mod. 704 with its small 4-K memory core. This limitation had forced the segmenting of research programs into small program parts, an expensive process adding to programming costs and slower computer operations. The small memory also threatened future research programs which required larger cores and which will include cyclotron and large multichannel analyzer and associated radiation shielding studies. Besides the 30-K memory, 5 additional magnetic tape drives and other associated equipments were installed. An off line printer system to be added to the computer facility was received and will be installed early in 1965.

RF SHIELDING EXTENSION FOR VAN DE GRAAFF BUILDING

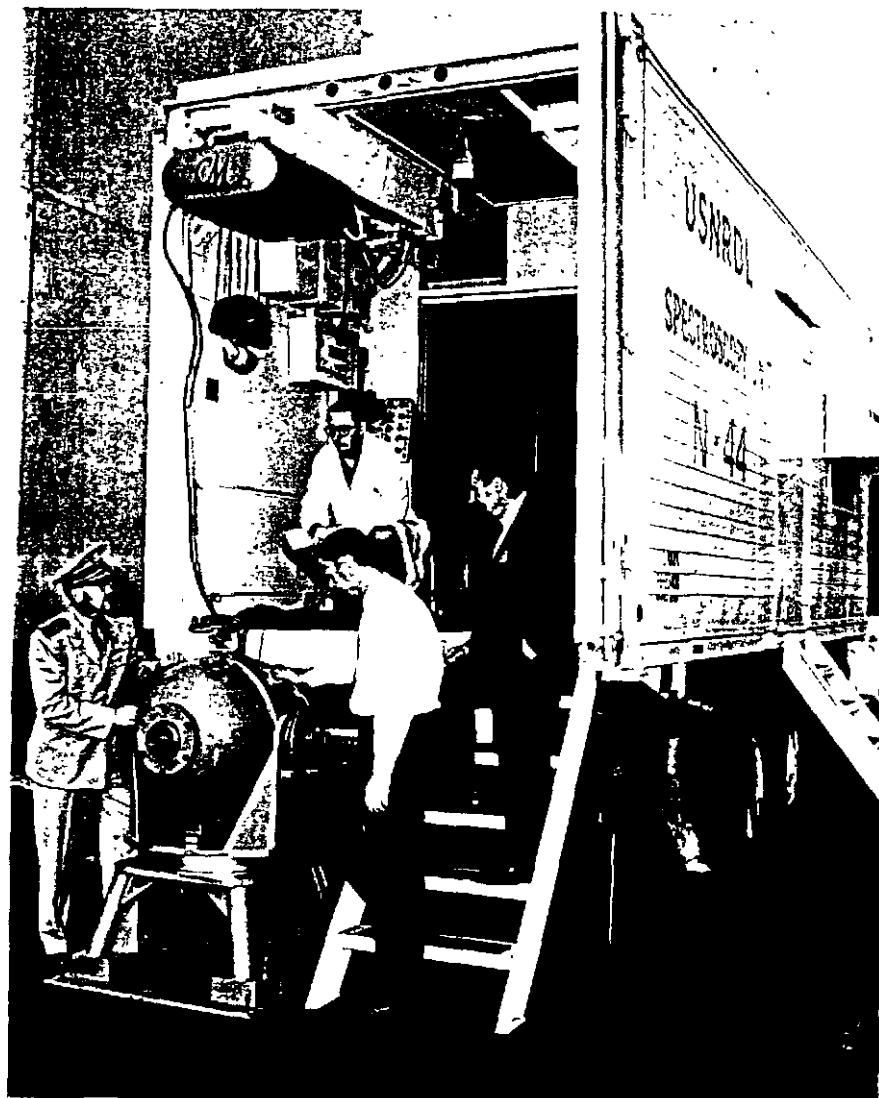
A NRDL building type RF shield extension to the east side of the Van de Graaff building was erected in June to provide RF shielding for experiments over the neutron pit adjacent to the building. Primary purpose of the unit is to eliminate extraneous RF signals generated by a nearby radio station. The technical program at the Van de Graaff has been concerned with studies of initial radiations associated with nuclear weapons.

SHIELD TO HOUSE 1 MEV X RAY MACHINE

Work was started on a shield to be completed about 1 May 1965 to house the 1 MeV X Ray machine. The research conducted with the use of the X-Ray machine consists of low level X-ray studies in multiple species and effects of protracted radiation on mammalian systems, sponsored respectively by DASA and the OCD.

ANIMAL FACILITIES MOVING OUT OF SHIPYARD

During past years objections were received from the San Francisco Naval Shipyard concerning animal research functions being carried on in the central part of the military housing area. The housekeeping problems and odors had come to be regarded as a health problem and remained objectionable to the Shipyard in spite of the Laboratory's best efforts to reduce them. Relocation of the animal irradiation and behavioral functions, located in an old barracks adjacent to the enlisted men's library, to a hot cell in the industrial part of the Shipyard, and move of the 1 MeV X-ray facility to the new radiation shield toward the northeast corner of the main Laboratory building, was initiated.



MOBILE SPECTROMETER COMPLETED -- CAPT D. C. Campbell, Commanding Officer and Director, inspects the new Mobile Spectrometer Laboratory which was built under the guidance of Horst Mey (right), project engineer. The Head of the Nucleonic's Engineering Shielding Program, Bruce Shumway (center), and his assistant, Allen Frank (on truck), will make major use of this facility. The 6,000 pound spectrometer can be placed at locations as far as 500 feet from the mobile laboratory proper. It can be pointed accurately at almost any angle and measures the energy distribution of the radiation from that direction. It can also be used within the mobile laboratory which is equipped with a 400-channel pulse height analyzer with facilities for either punched-paper tape or printed output. The punched-paper tape is brought back to NRDL and is transferred to the 704 computer for analysis. The facility is built to operate under all conditions of weather in the temperate and tropical zones. When fully equipped, it transports its load over all types of roads, trails, open rolling and hilly terrain.

CHAPTER II -- TECHNICAL PROGRESS AND ACCOMPLISHMENTS

A cross-sectional view of the research program, technical progress and accomplishments at NRDL during 1964 is shown through brief discussions in this chapter.

PROTECTION AGAINST NUCLEAR WEAPONS AND RADIATION, RADIATION MEASUREMENT

UNDERWATER NUCLEAR EXPLOSIONS DETECTION

The first phase of an operational analysis of the problem of locating and identifying the radioactive debris remaining after a clean underwater nuclear detonation in the open ocean was completed early in the year. Search vehicles, instrumentation needs and operational procedures were proposed, and a model based on these was developed predicting success of the search for the occasion in which there is measurable radioactivity at the water surface. Where there is no radioactivity at the surface, recommendations are less specific. One of the important inputs to the operations analysis was a method for predicting the size and intensity of the surface pool of radioactivity resulting from underwater detonation.

RAD RECOVERY OPTIMIZATION TECHNIQUE

An OCD-sponsored investigation by NRDL operations research personnel yielded a preliminary optimization technique for determining the earliest radiological recovery time for a military or industrial activity. The technique is based on the condition that the doses accumulated by the recovery personnel do not exceed certain prescribed limits. The most basic concepts of the method are presented, and fundamental aspects of the solution by a sample example are solved graphically. However, before practical numerical answers can be obtained, further theoretical work is required along with additional experimental and operational data.

ALASKA EARTHQUAKE RECOVERY

A NRDL countermeasures engineer made first-hand observations and evaluations of reclamation efforts in areas damaged by the Alaska earthquake of 27 March. These observations provided information on equipment and material requirements, and techniques and effort required to clear areas of heavy debris and to restore essential facilities. Such reclamation efforts are of particular interest to the Office of Civil Defense because of their similarity to conditions that would exist after a nuclear attack. Records of the Civil Defense operations in the disaster areas were also reviewed, and this information was assessed in terms of its value in planning nuclear attack reclamation. Findings indicated that conventional road-building equipment would be adequate for most rubble-clearing operations at reasonable times after a nuclear attack if operators are provided with respirators and protective clothing. Some modifications of equipment would be necessary to protect operators from radiation if clearance of rubble was required soon after attack. A need for stocks of water, pipe, wire, emergency power units, road building equipment, food, clothing, tools, and sanitation supplies was apparent.

SUGAR REFINERIES NUCLEAR ATTACK RECOVERY

Estimates of radiological recovery requirements for sugar refineries subjected in a nuclear attack to radioactive fallout, but not to blast, thermal radiation or initial ionizing radiation, were prepared for the Office of Civil Defense. This comprehensive study of man-day, manpower, materials and time schedule requirements was one of a series of studies on post-attack recovery of various types of major industries within the United States. These studies considered essential recovery requirements such as minor preattack modification of the plants to minimize equipment damage caused by the fast shutdown; need for adequate shelters for personnel and their families and availability of raw input supplies, and utility supplies and transportation facilities.

RADIATION FIELDS ASSESSING METHOD

A major contribution to a Defense Atomic Support Agency handbook on underwater nuclear explosions was made by the Laboratory in the form of a comprehensive study of the interaction of surface ships with the thermal and radiological environment resulting from surface or underwater nuclear bursts. The study covered the interaction of a ship with six classes of radiation: (1) thermal, (2) fireball plume, (3) transit, (4) deposit, (5) radiation from contaminated water, and (6) radiation from contaminated ventilation or combustion air. Current methods for predicting, at various

shipboard locations, the thermal and radiological effects of operational detonations were presented.

DIFFUSE RADIOACTIVE POOL DOSE RATES ESTIMATING METHOD

An operations research study completed in June developed an interim method for estimating dose rates above the primary radioactive pool produced by an underwater nuclear detonation. This information is required in the development of procedures for locating and identifying the radioactive debris remaining after a clandestine underwater nuclear detonation in the open ocean. It is also applicable to the problem of surface ship maneuvering after delivery of ASW nuclear weapons.

FALLOUT TRAJECTORIES, PROPERTIES CALCULATED

Culminating a study begun at the Laboratory in 1960, a program was devised during 1964 for computing the trajectories and changing properties of salt-slurry fallout particles resulting from a sea water surface nuclear burst. A computer program was conceived extending an earlier mathematical method that used manual calculation. Attempts continued to reconcile differences between Eniwetok Proving Ground test data and calculated or computed results. These discrepancies are believed to be mainly caused by faulty assumptions about atmospheric or particle properties and certain atmosphere-particle interactions.

ANALYTICAL MODEL DEvised FOR WAR-GAMING

An analytical model for ship damage and combat ineffectives predictions for war-gaming purposes was developed. The model considers the interactions of the immediate effects of nuclear weapon attacks on naval surface ships, ship's company, and embarked personnel. The analytical model generated data used to develop procedures which were forwarded to OPNAV for updating the nuclear weapon umpiring procedures in FXP5, Conduct of Fleet Exercises.

NUCLEAR REACTOR ACCIDENT STUDY

For aerospace applications of nuclear reactors, there is a need to determine the possible radiation doses to operating personnel or to others from radio-nuclides that might be released in an accident. In a study sponsored by the Pacific Missile Range at Point Mugu, NRDL investigators computed radio-nuclide activity inventories during buildup and

decay for short running times (1 sec. - 60 min.) of a hypothetical U235-fueled, 1 megawatt reactor with the results applying proportionately to all other power levels. The inventories were in the form of comprehensive tables of activity of all radio-nuclides occurring in the thermal-neutron fission of U235. Post shut-down inventories were given for reactor runs of 1, 5, 30, and 60 min. at 42-post shutdown times. The figures also showed the activity by chemical element and by isotope as a percentage of the activity of the element.

BIOLOGICAL INDICATOR OF SHOCK WAVES

A preliminary study was completed during the year, under a contract with San Francisco State College, of effects of shock waves on organisms. It was found that organisms belonged to the following groups: worms (oligochaetous annelids and freeliving nematodes), land isopods (crustaceans), beetles that spend all or most of their lives in the ground, ants, certain groups of soil bacteria, certain grasses and herbs showed shock effect. It was concluded that sufficient indirect evidence pertaining to shock energy effects on organisms exists to warrant laboratory tests simulating as nearly as possible the projected environmental conditions; and that any reasonably positive experimental findings should be further investigated.

TARGET VULNERABILITY STUDIES

This program has to do with a study of typical naval installations and their expected functional requirements after a widespread continental U. S. attack in order to estimate the effects of the attack on the facilities and personnel and to evaluate the capability of these effects to interfere with operations. Both damage assessment and physical and radiological recovery estimates have been included in this program. An idealized model was constructed and programmed for the NRDL computer. This program will be adapted to other BUSHIPS and BuDocks computer facilities for use in emergency recovery planning. Handbooks describing the effects of a wide range of hypothetical attacks upon typical naval shore facilities have been prepared.

INITIAL RADIATION, BASE SURGE HAZARDS IMPORTANCE EMPHASIZED

1964 marked completion of a fourth phase of a continuing study of requirements for military radiacs in which requirements for radiological data in tactical situations at sea spotlighted the importance of initial radiation of base surge involvement in a nuclear attack situation. The most recent weapons effects data updated the understanding of radio-biological effects and continuing examination of the latest data handling and data utilization aboard ships produced pertinent gamma and neutron dose and gamma intensity ranges, together with associated accuracy requirements for Command purposes at sea. The time available for collection and presentation of these data for various types of radiological environment involvement was computed.

MISSILE APPLICATION FOR NRDL THERMAL INSTRUMENTS

During a decade of nuclear weapons' field tests, NRDL has developed a series of unique radiometers and calorimeters designed to measure thermal radiation and to withstand the mechanical shock and intense radiation from such detonations. It has been noted during the year that modern technology has been developing other applications for the latest versions of the NRDL instruments and the associated NRDL calibration facility. For example, NRDL was requested to provide radiometers to be used to measure the thermal output from large-scale fires of rocket fuel at Edwards Air Force Base and in monitoring rocket launchings at Cape Kennedy to determine the temperatures reached in "aborts" where the booster burns on the launching pad. These calorimeters have also been used to calibrate the intense thermal sources involved in ablation studies of re-entry of vehicles at NASA, Ames Laboratory, and in thermal readings of aircraft structures at the Air Force Research Technology Division at Dayton, Ohio.

MANNED ORBITAL SPACE LAB PROJECT

One of two proposals from NRDL was accepted late in the year for inclusion in the Manned Orbital Space Laboratory Project of the Air Force. The NRDL project falls within the category of bio-astronautics experimental projects to assess man's utility and ability to perform military missions in space. Entitled "Heavy Particle Dosimeters," this experiment will have to do with measurement of the radiation exposure during space flight due to primary cosmic radiation, distinguishing between the proton

component and the heavy charged particle contribution. Total dose contribution from charged particles will be determined.

NEW RADIAC TO FIELD TESTING

Some 20 engineering models of an NRDL-BUSHIPS designed and developed radiac set (AN/PDR-65) were readied and sent to a number of Navy, Marine, Air Force and Army activities for field testing and evaluation. The new instrument measures gamma radiation, presenting a continuous display of both dose and dose-rate data. It is designed for use on individual mobile units, such as small naval vessels, armed scouting vehicles or tanks, or at infantry Command posts.

NO FAST NEUTRON RADIOGRAPHY 'ADVANTAGES'

Experiments were conducted over a six months period in photographic detection methods applicable for fast neutron radiography. These turned up important, though negative, results to the effect that fast neutron radiography was found to offer no advantage over conventional radiographic methods. On investigating neutron response at different photographic emulsions, improved response was noted where the films were exposed in contact with organic phosphor materials. However, lack of discrimination between the different materials exposed to neutrons limited the use of the technique to the reasonably large section of homogeneous materials.

HIGH TEMPERATURE EMITTANCE PROBLEMS

Available high temperature emittance data had never proved too reliable principally because high surface temperatures were difficult to measure accurately, and it was not possible to quantitatively describe the fundamental emittance properties of a material unless accompanied by exact surface characterization. At the request of the Air Force Materials Laboratory, interested in such phenomena in connection with nose cone and other missile studies, NRDL produced new findings on radiative properties of tantalum, niobium, tungsten and molybdenum. Experimental data were developed as guidelines for more detailed accounting of electronic relaxation time, internal photoelectric effect, bound electrons and other short wave length phenomena. It is hoped that this guide will lead to the generation of a worthwhile theory accurately describing the radiative properties of electrical conductors at high temperatures.

FAST COINCIDENCE SPECTROMETER

Completion of a new Fast Coincidence Nuclear Radiation Spectrometer was announced in June. This spectrometer can be regarded as a "state of the art" in nuclear structure research. The spectrometer considerably advances the capability for study of the radioactive decay schemes of radioisotopes, which lead to a further knowledge of energy level structure and the properties of the nuclear forces.

RADIATION EFFECTS IN PHOTOTUBES

A factor influencing the performance of multiplier photo tubes exposed to nuclear burst ionizing radiation has been found to be the radiation-induced luminescence of the tubes' glass envelopes. NRDL researchers found that this sensitivity can be reduced significantly through the use of non-luminescent materials in tube construction. It was also noted that in some applications, improved performance can be realized by proper tube-type selection.

PHOTOGRAPHIC READOUT SYSTEM

NRDL physicists came up with a newly conceived photographic readout system for recording rapidly changing mass spectra generated by a time-of-flight mass spectrometer instrument wherein two oscilloscopes equipped with Polaroid-Land cameras are used together with special techniques for rapid analysis of gaseous products resulting from the millisecond-duration of flash pyrolysis of polymers.

ELECTROMAGNETIC 'SIGNALS' THEORY DISPELLED

Implications from other scientific investigators that electromagnetic signals of 15 sec. in the frequency band below 1.0 cps had been observed from 10-gram chemical explosions in air or water led to a thorough check-out project. NRDL interest centered in the possibility of the existence of similar signals from underwater nuclear detonations in terms of determining a long-range means of detection of such bursts. Through a series of tests and other measurements made to isolate direct cyclic and instrument signal sources, it was concluded that the electric signals recorded resulted principally from electric fields produced by the explosions and that there exists the possibility that all signals observed rose from quasi-static electric fields, not charged particle explosion clouds postulated by existing theory. The electro-magnetic nature of the signals was not verified and additional experiments would be required to provide an absolutely conclusive answer regarding the source of these signals.

MICROCALORIMETER STUDIES

Calibrations of the two laboratory secondary standard microcalorimeters (one with beryllium absorber and one with polyethylene absorber) have been extended over a temperature range of several degrees above that of liquid nitrogen. These additional calibrations were necessary because both thermistor sensitivity and the specific heat of the absorber are dependent on temperature. The polyethylene absorber was found to have approximately $1/6$ as large a dose sensitivity as that of the beryllium absorber, primarily because of the higher specific heat of the polyethylene. Using the Laboratory 250 KV Westinghouse X-ray machine as a source, comparisons were made between the absorbed dose as measured with the microcalorimeter (beryllium absorber) and exposure level as measured with an ionization chamber for X-ray energies from 50 to 250 KV. Trial exposures of the beryllium absorber microcalorimeter to 900 MeV alpha particles were made at the University of California Lawrence Radiation Laboratory 184-in. cyclotron. Results of these exposures are being analyzed.

The calorimeter proposed for field use was modified by the addition of a second calorimeter with a matching absorber and thermistor. It is expected that the use of the second thermistor as a comparison arm in the detecting bridge circuit will minimize the effects of changes in environmental temperature. Evaluation of this system is in progress.

ELECTRONIC RELAXATION IN METALS

Based on the Drude model, equations were derived by NRDL investigators in a basic research project sponsored by ONR for the spectral total normal and total hemispherical emissivity of metals in terms of their absolute temperature, electrical resistivity and relaxation time. Some emittance data on the polished metals were graphed for comparison with these equations and it was concluded that other factors need to be taken into account in order to obtain a quantitative set. Also, the spread in emittance data for the same materials suggested the need for more reliable emittance measurements.

JOINT EXPERIMENT WITH NEL

A joint experiment with NEL at their Oceanographic Research Tower was initiated to differentiate water masses, marine animals and plants, etc., by measurement of their respective radioactivities. First results from this experiment, which should give important clues to oceanic processes, have established that radioactivity of plants and animals can be measured under these conditions but that more sensitive instruments will be necessary to identify water masses.

OCEANOGRAPHIC, RADIO-CHEMISTRY, FALLOUT STUDIES

PACIFIC OCEAN FALLOUT EVALUATION

Another step into a growing oceanography research program was taken with a project concerned with the interaction of radioactivity in the atmosphere and in the oceans. Both naturally occurring and artificially produced radionuclides will be considered in this project involving studies on the background levels extant and the changes in inventory due to introductions from existing and projected future sources. Initial phase of the program is concerned with an evaluation of the global fallout in the North Pacific Ocean. The USNS DAVIS (AGOR-5), a 210 ft. oceanographic vessel, commissioned for employment by the West Coast Naval Laboratories, was used for a 2-week expedition to take water samples at three locations, starting with an area some 500 miles off the California Coast. Samples will be taken at depths as great as 2500 meters.

HIGH-TEMPERATURE CHEMISTRY GAINS

The distribution of fission products following a detonation depends upon the chemical processes that occur in the fireball. To study these processes requires the use of high-temperature chemistry. New techniques and apparatus were developed and employed to extend measurement range capability to ever higher temperatures. Isopiestic techniques, bi-isothermal furnaces, plunging drops, and fluidized beds are all used or available to obtain thermodynamic and kinetic data on fission product condensation above 1000°C.

Molten salt research was also an active field. Here, liquid and solid ion exchangers have been developed to process molten salts in ways similar to those employed on aqueous systems with organic cation exchangers. Orders of cation selectivity can be varied by suitably chosen combinations of salt and exchanger. It was found that separation factors achievable equal and sometimes even exceed those in aqueous systems.

SHORT-LIVED FISSION PRODUCT STUDIES

A limiting factor in the accumulation of nuclear data on short-lived fission products has been the lack of adequate methods for the very rapid separation and purification of individual nuclides from fission product mixtures. Work in this area at NRDL during the year produced radiochemical methods by which separation and purification of Sn, Sb, As, I, Cd, In and Ag are accomplished within from 3 to 10 seconds of removal of the

fissionable material from an irradiation source. A significant development made possible by development of these rapid radiochemical methods was the discovery of Cd^{121} , a short-lived radionuclide not previously identified.

HIGH SPEED READOUT SYSTEM FOR ANALYZERS

The answer to a long standing need for techniques for coupling the pulse height analyzer to the computer in analyses of pulse height spectra was announced in October. The answer took the form of a high speed punched card readout system for a 256-channel pulse height analyzer utilizing an IBM-523 Gang Summary Punch. The readout system accepts information in binary form, and punches binary form directly onto cards. It also converts binary-coded-decimal information into binary format. Each data record is uniquely identified by seven data identification and information words which are automatically entered through an AND gate matrix. Most significant advantages are speed of readout, ease of organizing an efficient data file, and human, as well as computer, accessibility to the data.

UNDERWATER DETONATION BUBBLE ACTION STUDY

In order to describe the early radiation field resulting from a shallow underwater nuclear detonation, knowledge is required of the hydrodynamic mechanisms that transport the radioactive debris in space and time. Studies of the motion of the explosion product bubble in an underwater chemical detonation reveal a definite need for a more general description of bubble motion for the important fission bubble cycle. To satisfy this need, NRDL investigators came up with a model which approximates the actual bubble motion during its first cycle in terms of a non-spherical bubble undergoing a radial expansion and contraction in the presence of a free surface and gravitational field. Comparison with photographic data and with a common spherical approximation indicated that this model yields a more accurate description and a better understanding of explosions in the near-surface region.

UNDERWATER 'SHOTS' ABOVE-SURFACE ACTION FIXED

Stemming from the HYDRA II shallow underwater high explosive shots, a study was completed of the critical effects of depth on the atmospheric distribution of explosion products, as suggested by very shallow nuclear explosions. A definite effect of detonation depth on the occurrence of the release of explosion products to the atmosphere was indicated and

the critical depth at which the transition takes place was determined. Also, qualitatively, it was found possible to describe the roles of the various above-surface phenomena in the distribution of explosion products and the effect of the physical state of the explosion products on their distribution.

FISSION YIELD STUDIES

Theoretical calculations of the relative abundances of individual radionuclides in the fission product mixture at early times after a nuclear detonation have been seriously hampered by large gaps in the experimental data. Of particular concern was a lack of data in the region of closed nuclear shells (nuclides having 50 protons and 82 neutrons). It was suspected that the closed nuclear shells might influence the probability of formation of nuclides and thus influence the relative abundances to an undetermined extent. In order to remove this uncertainty in the calculations, experimental measurements were made of the fission product yields of members of the 131, 132 and 133 mass chains. These measurements have now established that the nuclear shells produce no detectable effect upon the probability of the formation of fission product nuclides in this mass region. A major experimental check point was thus established in the calculations of relative abundances and a significant uncertainty in the validity of such calculations has been removed.

COSTA RICA VOLCANO FALLOUT 'EXPEDITION'

During April, a group from NRDL was sent to Costa Rica to study OCD program-related aspects of the sand-like fallout resulting from the almost continuous eruption of the volcano Irazu. This volcanic fallout which was continuing to a greatly diminished degree at the end of the year, while non-radioactive, otherwise closely resembled that resulting from near surface or underground nuclear explosions. Ingress, redistribution patterns, retention on roofs and other surfaces, and effects on ventilation filtering were studied. First results indicated that an otherwise high protection factor (the factor by which the radiation field in a shelter is lower than that outside) may be reduced to as low as 200 in the vicinity into which air is moving. Inexpensive furnace-type filters were found to be ineffective in preventing ingress of fallout. However, it appeared that very simple countermeasures could be employed during, or at the cessation of fallout to re-establish high protection factors.

MATHEMATICAL MODELS SYSTEM BREAKTHROUGH

A significant contribution to statistics, specifically to construction of mathematical models and interpretation of experimental data, was developed by a NRDL mathematician during the year as a by-product of Hydra project investigations. This system consolidates the often fragmented approach found in many statistics handbooks and other tests. A general quantitative system for association of theory and observation is presented, directed toward user needs and well organized for use with automatic computing and information processing machines where large amounts of data are involved.

UNDERWATER BURST STUDY

Some 51 private industry firms, representing a cross-section of the nation's aerospace industry, showed interest in a contract for research on final development of an aerial nuclear probe system to measure radiation within the plumes and columns thrown above an underwater nuclear explosion. This is part of a continuing Laboratory program to generate ability to predict distribution of fission products in the column and resulting radiation fields for various yields and burst geometries. The system to be developed consists of beta and gamma radiation transducers coupled with a telemetry transmitter which makes up the payload of a short range, high weight-to-drag ratio rocket. Work started on the contract in late November and will involve development of a technique derived from previous contracts and weapon test experience.

MANGANESE-56 SEPARATION ACHIEVED

NRDL chemists devised a method whereby manganese-56 can be effectively separated from other radio-induced nuclides and from gross fission products. The method employs an anion exchange column to effect the separation. Sodium is separated from other alkali metals and from gross fission products by precipitation of the fission products and by separation of alkali perchlorates by non-aqueous precipitation. The methods devised allow the use of any gamma detector, such as a pulse height analyzer or a 4-pi ionization chamber, to determine the amount of separated sodium-24 or manganese-56.

USE OF STREET FLUSHER FOR FALLOUT REMOVAL

Tests were completed for the Office of Civil Defense of the effectiveness of a motorized street flusher under controlled environments of

simulated fallout, using optimum machine adjustments. These tests as part of radiological recovery programs turned up the following: a). Contaminant removal effectiveness is maximum when hose nozzle, general stream planes intersect the surface in one straight line; b) For a given amount of effort the rate of removal as well as lowest, finest residual mass obtainable is a direct function of particle size and an inverse function of mass loading; c) Highest degree of effectiveness was achieved on concrete surface at low mass loadings with the large particle sized range; and a d) previously developed theoretical cleaning equation for the data for 13 out of 22 of the tests.

TRITIUM

An apparatus for reproducible contact sampling of a contaminated surface has been built and evaluated. Measurement precision was found to be a strong function of the surface smoothness and also of contaminant activity volatility. The apparatus was developed for tritium contamination studies but is expected to be of considerable value in related areas such as the evaluation of decontamination techniques.

RADIOLOGICAL RECLAMATION

An evaluation study of soil cutting as a decontamination procedure showed that mechanized soil cutting combined with removal methods form an effective reclamation procedure. Although removal effectiveness was shown to be a function of effort and mass loading, sod and turf conditions were found to be more governing than contaminant particle size.

RADIONUCLIDE RELEASE TO SEA WATER

Potential hazards associated with the accidental introduction of nuclear power source materials into the ocean are being determined in a continuing project by studying the ways in which the radioactive fuels can be dissolved by sea water. One part of this problem is to determine the rate at which the container material for the fuel is corroded by sea water in its own high radiation field. The other part is to find the rates at which the fuels such as strontium titanate, plutonium metal, and plutonium dioxide are transported away from the source once the container material has corroded and to understand the chemistry involved in the reaction of the fuel with sea water.

BIOLOGICAL RESEARCH

The Biological and Medical Sciences Division 1964 research program also included effort in the field of oceanography. Feasibility studies in the area of biospheric contamination led to two major experimental programs, one for BUSHIPS concerning radionuclide uptake by photosynthetic marine plankton; and the other, funded separately under Office of Civil Defense, concerning uptake by roots of vascular plants. These experimental approaches were restricted to the primary biospheric level, where radionuclides leave the physical environment and first enter food chains. Their initial aim is to establish unambiguous quantitative measures of the uptake rate of individual radioelements, using systems whose chemical properties can be defined.

BIOLOGICAL EFFECTS OF RADIOACTIVE MATERIALS

Using the isolated rat stomach as a test preparation, whole body irradiation has been found to inhibit the sodium transport mechanism located in the mucosa and normally operating to resorb gastric sodium. This mechanism was definitively characterized and its bioelectric activity shown to measure sodium transport. The irradiation was a complex, secondary response; and experimental studies were made to resolve the radiosensitive components. Feeding regimen, pathogen activity and pyridoxine metabolism were implicated, but specific experimental investigations of these factors showed their effect to be indirect.

MODIFICATION OF RADIATION RESPONSE

A clear dissociation between skin homograft tolerance in allogeneic mouse radiation chimeras and the synthesis of donor type γ -globulins was demonstrated. Inhibition of urethan-induced lung tumor formation by whole-body X-irradiation was shown to be radiation dose dependent. It was shown that the maturation of "potential" immunologically competent cells in fetal liver is dependent on intact thymic function. In adult thymectomized irradiated mice restored with isogenic marrow, the greatest defect in the homograft reaction is with respect to skin homografts from donors genetically very similar to the recipient. Exposure to low dose-rate γ radiation (1.45 rad/hr) produced a marked increase in liver and ovarian tumors in mice, relative to high dose-rate X ray.

IMMUNOLOGICAL ASPECTS OF RADIATION INJURY AND RECOVERY

Cell transfer of either macrophages or lymphocytes incubated with bovine gamma globulin (BGG) into X-irradiated rabbits did not restore antibody formation. Sensitized macrophages and normal lymphocytes injected together did result in the formation of anti-BGG antibodies by irradiated rabbits. A tissue culture technic of maintaining lymphocytes which have taken up RNA from a plasma cell tumor was developed. This technic will be used to determine synthesis of myeloma globulin by non-plasma cell tumor lymphoid tissue.

RADIATION EFFECTS ON ORGAN GROWTH AND FUNCTION

The dramatic differences between the effects of ischemia and of anoxia on bile secretion in the rat liver were subjected to further analysis. The experiments provided further support for the view that humoral factors, presumably the transport of metabolites away from the tissue, are of major importance in producing the prompt bile stasis of ischemia.

The comparative studies of several volatile anesthetics on liver function were resumed. Marked differences between ether, chloroform, and halothane were demonstrated. These included: vasodilatation, virtually absent with ether, depression of oxygen consumption, most marked with chloroform, least with ether, and suppression of bile flow by far the most marked with chloroform.

DELAYED AND LATE EFFECTS OF RADIATION

The first phase of the study of accumulation of lethal injury by repeated exposure to X ray was completed and published. Another completed study presented a review and analysis of the available data to date on accumulation of lethal radiation injury from chronic exposure. A series of experiments on response of rats to cold environment was completed, and analysis of the result is in progress. Studies on early biochemical changes after tissue injury were discontinued, and a report started of the results.

CELLULAR AND SUBCELLULAR BASIS OF RADIATION INJURY

What may be a fundamentally important substance, a DNA-RNA complex, not previously known, was discovered and isolated from normal rat liver tissue. Stimulation of incorporation of tritiated thymidine into DNA by mouse spleen cells in tissue culture was achieved, by culturing mouse

spleen cells with rat cells. These results suggest primary antibody synthesis by these cells in vitro. An abscopal (indirect) inhibitory effect of whole-body X irradiation on kidney cell mitosis was observed.

CELLULAR KINETICS AND RADIATION RECOVERY

Simultaneous measurements of DNA content and the rate of synthesis of DNA have been made in nucleated erythroid marrow cells of animals. The measurements of DNA content were accomplished with a microspectrophotometer of high precision designed and built in this Laboratory. The measurements of DNA synthetic rate were made by autoradiographically measuring the extent of incorporation of C^{14} labelled thymidine after a brief in vitro exposure to the label. It was shown that DNA synthesis appears to be intermittent in this class of cells, since it is possible to find cells of any DNA content which are not in DNA synthesis as judged by uptake of the label. It was shown, also that the variability in DNA synthetic rate predicted from autoradiographic evidence is not decreased when the cell population is divided into sub-classes based on DNA content.

THE EFFECTS OF IONIZING RADIATION ON SUSCEPTIBILITY TO INFECTION

Listeria monocytogenes persists in the lungs and proliferates to a greater extent in the livers and spleens of mice exposed to a total dose of 500-2800 rad γ radiation administered continually at 1.0-1.5 rad/hour. The irradiated mice also exhibit a decreased ability to develop an immunity to the infection. Mice exposed to 690 or 720 rad were found to have a decreased number of peritoneal cells 24 hours post-irradiation. The decrease was due to a loss of lymphocytes, the macrophages remaining constant. The macrophages decreased slowly over the next 3 weeks, but returned to normal levels within 30 days.

TREATMENT OF RADIATION INJURY BY HOMOLOGOUS BONE MARROW TRANSPLANTATION

Data developed showed that even at an 100% lethal X-ray dose to mice, there is a residual host immunological barrier to an allogeneic marrow graft. The additive suppressive effect of combined radiation-chemotherapy (urethan) on the homograft response of mice may be mediated, in part, through greater injury to thymus. Successful and prolonged transplantation of allogeneic marrow, without secondary disease, is feasible in dogs if the marrow donor and recipient are properly matched. In mice, if the allogeneic marrow donor and recipient share the same H-2 transplantation antigen genotype, transplanted donor marrow or lymphoid cells may persist indefinitely after even a sublethal X-ray dose (500 rad) to the recipient.

EFFECTS OF RADIATION ON THE NERVOUS SYSTEM

The immediate reactions of the nervous system to low dose X-ray exposure has been investigated. Electroencephalographic activation can be detected in resting or sleeping animals within a few seconds after the onset of irradiation. Studies progressed to determine if the neural reactions are the result of direct effects of ionizing radiation on neural tissue or receptor systems or both.

CRITICAL ORGAN STUDIES

The kinetics of systemic recovery from radiation injury have been determined for seven species of animals by means of the split-dose technique. The curves that relate the percentage-remaining-injury to time-after-conditioning-dose, show significant departures from the expected exponential pattern in four of the seven species: In two cases a secondary radiation sensitivity was detected after considerable recovery had occurred. In another case, the curves showed a pronounced shoulder indicating that little recovery occurred during the first days after the conditioning dose. In still another case, a highly significant radio-resistance was shown to follow the period of exponential recovery. This radio-resistance lasts for at least 100 days. The time required to recovery from 50% of the initial injury has been estimated for each of the seven species. These recovery half-times range from 2-18 days.

EFFECTS OF IRRADIATION ON PERFORMANCE AND BEHAVIOR

Studies of the persistent or delayed effects of X-ray and neutron exposure have been directed toward the analysis of deleterious effects on growth. Bone growth measurements were made in animals which survived a dose in the 30-day lethal dose range or were subjected to a high sublethal dose of radiation. In animals exposed as young adults, a reduction in bone length could be detected at the end of the life span. The degree of reduction was dependent on the dose and type of radiation. Neutrons appeared to be about twice as effective as X ray with respect to bone growth inhibition in the rat. Thus it appears that both neutron exposure and X irradiation produce a permanent deficit in bone length, and that the magnitude of the stunting effect is dose dependent, with a threshold below 230 rad of neutrons and 430 rad of X ray.

EFFECTS OF PROTRACTED RADIATION ON MAMMALIAN SYSTEMS

Animals were exposed to a fixed total dose of 165 r at dose rates of 0.5, 1.0, 1.85 and 3.9 r per hour. The extent of injury accumulation

during the chronic exposure was evaluated on the basis of the extent to which the chronic exposure lowers the LD₅₀. At the rates of 0.5 and 1 r/hour, the animal's LD₅₀ was not lowered as a consequence of the chronic exposure; however, at dose rates of 1.8 r/nour and 3.9 r/hr, 35% and 63%, respectively, of the injury produced by the exposure dose was detected. The threshold dose rate at which injury accumulates in sheep exposed to this fixed total appears to lie between 1 and 1.8 r/hr.

RADIOPROTECTIVE EFFICACY OF WR-1607

Studies were continued on evaluation of the radioprotective efficacy of WR-1607 for lethally irradiated large animals. A total of 37 irradiated animals received intravenous injection of this compound (15 mg/kg or 20 mg/kg) immediately prior to exposure to 1 mvp X rays (bilateral exposure). It was evident that WR-1607 have exhibited radioprotective activity in irradiated animals in the dose range 400 rad up to 500 rad. (There were no survivors after 600 rad exposure, in 4 animals.) The animals surviving the otherwise lethal exposure, under these conditions, invariably showed beginning recovery of their peripheral blood leukocyte counts during the third week post-irradiation. Irradiated controls, not injected with the compound, died within 12 to 29 days, and without signs of recovery of their peripheral leukocyte counts. It will be noted, too, that survival of the small group of animals receiving penicillin after irradiation, in addition to WR-1607 prior to exposure, showed a higher percent survival (37.5%) than similarly irradiated animals receiving WR-1607 only (18% survival). Evaluation of additional compounds, e.g. WR-2529 was started.

BIOLOGICAL UPTAKE OF RADIOELEMENTS BY PLANTS

A detailed report of the characteristics of calcium transport from 2.5 mM CaCl₂ solution was published marking completion of a phase of an OCD study on biological uptake of radioelements by plants. With improved nutrient solutions presently used, rather similar features were observed as follows: The direction of maximum calcium transport under stabilized conditions reflected the original orientation of the root segment in the intact plant, namely from root tip to ground level. This has been termed basipetal transport. Under fully polarized conditions, e.g., at 20 hours, basipetal transport exceeded acropetal transport (transport in the opposite direction) by at least a factor of 20. Usually after twenty hours, transport gradually decreased, indicating the probable depletion of metabolic substrate. Maximum transport of calcium--taken as the limiting basipetal value under steady state conditions--may vary from 2 to 20 nanomoles Ca per hr depending on concentration, viability, and other factors as yet to be definitively established. Some preliminary

observations have been completed with Sr^{89} . The transport features for roots immersed in Sr^{89} are remarkably similar to those established for calcium, i.e., transient high peaks following the initial trauma of sectioning, then fully polarized basipetal transport at about 14 hours, based on radioactivity counting rates. The usual nutrient solutions were used with carrier strontium at 0.25 mM concentration. Systematic observations were continued on the several factors needed to establish correct magnitudes for the transport rate of ionic strontium, e.g., effects of carrier, concentration dependence.

RADIATION DAMAGED CELL REPAIR PROBED

In a continuing biological study to determine how repeated daily exposure of animals to moderate doses of X ray accumulates eventually to an effective lethal dose, the exact LD_{50} in mice given daily exposure to X rays was measured for exposure periods of 5, 10, 15, 20, 30, 40, and 60 days, and also for a sequence of 3 days' exposure alternating with 3 days' nonexposure, for a total of 9 doses in 15 days. Except for a 5-day exposure series, the LD_{50} for the daily exposures was increased above that for a single lethal dose almost in proportion to the number of doses given. The classic Blair Model (exponential decay of injury with time) did not fit the data. It is tentatively concluded that a biological mechanism, involving prompt repair of injury in cells which survive each radiation exposure, may account for the relation between number of exposures and increase of LD_{50} .

THYMECTOMY RADIATION EFFECTS

A study for BuMed concluded during the year showed that adult thymectomized, irradiated mice restored with isogenic bone marrow cells are permanently impaired immunologically with respect to the rejection of primary skin homografts. It was also noted that the deficiencies in skin graft response are most pronounced when the donor and host are closely related genetically.

LIVER/BILE STUDIES

Laboratory biologists, studying the contribution made by the bile to the composition of hepatic lymph in rats, found indications of leakage of bile components into the extra-cellular space. This suggests a mechanism of jaundice based upon failure of the mechanisms normally separating the biliary and extra-cellular spaces. There was also an indication that the BSP (used in testing liver function for a measure of hepatic dysfunction) in hepatic lymph is normally derived from the liver cells rather than from the blood plasma and that the lymph is formed in the region of the sinusoids or the central vein of the liver.

BONE STUDIES

The most recent finding in a long-term study of effects of neutron exposure on bone structure of rats showed growth deficits at the end of lifespan. Magnitude of reduction in bone length at the end of lifespan was found to be dependent on radiation dose and age of the animal at the time of exposure. A greater stunting of growth effect of neutron exposure of rats exposed as juveniles was explained on the basis of faster growth rate of young animals.

TRITIUM TRANSFERRED BY CONTACT

Bio-medical research confirmed that tritium can be transferred from contaminated metal by contact, that the radio-activity absorbed enters the body water and that it follows the metabolic pattern of tritium entering by other modes.

RADIATION EFFECTS ON BODY'S 'MASTER MOLECULE'

In each cell of the animal (or human) body is a "master molecule" deoxyribonucleic acid (DNA), which contains in code form all the information needed for development, function and identity of the animal. It is believed by many investigators that one of the principal effects of ionizing radiation on the animal may be damage to this master molecule. However, conclusive proof for this concept has not yet been forthcoming. In efforts to investigate this problem, NRDL biologists separated DNA from the cells of various body organs, some irradiated and some not, in order to look for differences at the molecular level. It was found, unexpectedly, that the DNA from the liver behaved differently from DNA of spleen or thymus, whether irradiated or not. Since spleen and thymus are highly radiosensitive and the liver is relatively less sensitive, it was important to look into possible differences between liver DNA and the DNA

from other sources.

It was found that the DNA from liver was always contaminated with about 30 per cent of a related substance, ribonucleic acid (RNA), while thymus or spleen DNA were not contaminated with RNA. Further study disclosed that the RNA was actually bound to the DNA in the liver preparation in a manner which altered the physical and chemical properties of the DNA, as measured by response to thermal denaturation, degradation by nucleases, and behavior in a sucrose gradient. Whether the attachment of RNA to the DNA in the liver cells is related to the radiation-resistance of liver is to be investigated as are other aspects of the physiological significance of the DNA-RNA complex in liver.

GAPS IN NEUTRON RADIATION INJURY KNOWLEDGE

A review of data conducted during the year from many independent sources indicated that there are significant gaps in knowledge of the process of accumulating of injury by neutron radiation. However, the literature review indicated that discoveries about the kinetics of accumulation of radiation injury by cultured mammalian cells have made possible a more unified view of the process of injury accumulation in whole mammals with a reconciliation of many once divergent experimental viewpoints. This new unity of view promises increasingly improved understanding of the process of accumulation and repair of radiation injury in animals.

IMMUNO-THERAPY OF SOME MALIGNANT DISEASES

A basic Bio-Med research study turned up findings which may have some indirect value in the medical and biological sciences multi-directional research attack upon known malignant diseases. Data were developed which indicated that the aggressive growth in vivo of transplanted leukemic cells in mice can be significantly altered under sublethal X radiation conditions that involve a temporary take of injected genetically foreign spleen cells. This is an order to initiate a short limited graft vs. host reaction against the implanted leukemic cells. On the basis of these, other findings, and certain theoretical considerations the possible use is suggested of stored and/or frozen, non-irradiated autologous human peripheral blood leukocytes, as therapeutic agents for "immuno-therapy" of selected types of human malignant disease when used in appropriate conjunction with radiation and/or chemo-therapy.

OTHER RESEARCH PROGRAM DEVELOPMENTS

CORE PROGRAM ACCELERATED

Due to an increase of CORE Program funds beginning 1 July 1964, the Laboratory has increased its work in this area. Emphasis is being placed on nuclear studies tied in with cyclotron research and on environmental studies including the oceans and space.

'PERT' SYSTEM USE EXPANDED

Two of the Laboratory's Scientific Divisions early in the year embarked upon a relatively large field-type radiation measurement and detection instrumentation development program requiring the awarding of several outside contracts and a significant in-house scientific effort. The program, sponsored by the Defense Atomic Support Agency, lent itself to employment of the 'PERT' (Program Evaluation and Review Techniques) system to be used in progress reporting. This management tool was used not only to satisfy the requirements of DASA, but to obtain the most desirable level of program control where the program is diverse and allowable time for completion short and fixed.

NRDL TEAM AT PROJECT 'SALMON'

As part of the continuing Project ARNE (Aerial Reconnaissance of Nuclear Explosions) Research Program on aerial on-site inspection, a research team directed by the NRDL Technical Management Office conducted extensive aerial reconnaissance and ground environmental data acquisition efforts during the SALMON underground nuclear test conducted in October near Hattiesburg, Mississippi. The NRDL program included nine aircraft equipped with five different categories of image and non-image forming sensors and four two-man ground teams equipped with various environmental probes. Ground environmental data collection took place simultaneously with the aircraft overflights to enable interpretation of the airborne imagery in terms of the environmental characteristics.

III -- PUBLICATIONS

REPORTS AND MEMORANDA

Technical publications production continued on a rising curve during a busy year. Requests of sponsors for short-term, immediate need operations research oriented military applications studies increased. Consequently, the relatively new reporting series, the informal, "quickie" LR (Letter Report), sent to specific requesting codes, was conspicuous in the Laboratory reports output. Several of these letter reports represented rather extensive efforts by the Military Evaluations and Chem Tech Divisions. Technical papers, reports, and memoranda produced by NRDL personnel for sponsors in other than Laboratory format or those produced by an outside contractor carried the number "X" after the number, e.g. TFX, TRX, TMX. (*) The TRXs and TFXs have a separate group of numbers due to their volume; other series are numbered consecutively with the "X" reports included. Contracted research reports began to take a prominent place in the information output.

Reports and publications output for 1964 shaped up as follows:

U. S. Naval Radiological Defense Laboratory	
Report (Formal).....	5
Technical Reports (USNRDL-TR).....	109
Technical Memoranda (TM).....	9
Progress Reports (PR).....	23
Evaluation Reports (ER).....	1
Letter Reports.....	43
Reviews and Lectures (R and L).....	13
Total.....	203

Also *

Technical Papers published externally (TFX).....	6
Technical Reports " " (TRX).....	3
Technical Memoranda " " (TM).....	1
Total.....	10

PUBLICATION IN THE OPEN LITERATURE

Nineteen papers and articles by NRDL authors were published in 11 journals during 1964.

OTHER PUBLICATIONS

Nuclear Weapons Research Capabilities of NRDL
An Informational Guide to NRDL
Preliminary Technical Manual for the AN/PDR-65 Radiac Set
Target Vulnerability Handbooks (Preliminary)

PATENT ACTIONS DURING 1964

Four patents were issued: (1) Dr. N. E. Ballou and E. M. Scadden, "Method of Solvent Extraction," Patent No. 3,125,410. (2) R. L. Hopton and E. J. Wesley, "High Speed Digital Register-Counter," Patent No. 3,120,925. (3) N. A. Marshall and G. A. Work, "Pulsed Gas Tube Electrometer," Patent No. 3,115,595. (4) H. A. Zagorites, L. A. Perrine and M. I. Lipanovich, "Portable Gamma Intensity Time Recorder," Patent No. 3,154,686.

There were 13 patent applications pending and eight patent disclosures under development.

CHAPTER IV

AWARDS -- COMMENDATIONS -- HONORS

PRESIDENTIAL CITATION

NRDL received the Presidential Citation in special recognition of an outstanding contribution to greater economy and improvement in Government operations during the 10th anniversary year of the Federal incentive awards program.

COMMENDATION FOR NEWRADS

The NEWRADS (Nuclear Explosion Warning and Radiological System) technical development plan prepared at the request of BUSHIPS in anticipation of an advanced development objective requirement and submitted by NRDL on 1 July, resulted in a commendation letter from the Chief, Bureau of Ships. The last line of the letter read "efforts such as this enhance the already high esteem in which the Bureau holds the Laboratory."

SUPERIOR CIVILIAN SERVICE AWARD FOR A. E. SMITH

Mr. Albert L. Smith, Head, Health Physics Division, on 15 May was presented a Superior Civilian Service Award (the highest that a Bureau Chief may grant). "I consider it exceptionally well deserved," wrote RADM W. A. Brockett, Chief of the Bureau of Ships. "You assumed a great personal risk and displayed the utmost courage..."

At the conclusion of some experimental work at the Camp Parks Cobalt 60 Range on 21 April, one of the 3,000 curie Cobalt 60 sources did not return to its proper resting position in the shielding pig. Mr. Smith was not only largely responsible for the planning which led to the release of this source but volunteered to perform the actual hazardous task of freeing it from its point of binding. He achieved this by approaching the source with a long pole, following a meticulously planned timing schedule to a fraction of a second and with a minimum radiation exposure

to himself of about 1/3 of a roentgen. (Mr. Smith was also one of six employees to share in a \$300 group Superior Achievement Award as a consequence of the problem at Camp Parks.

GOLD/SILVER AWARDS TO DRS. TYAN AND SCHIEVE

Dr. Marvin Lee Tyan, who gave up a successful medical practice in internal medicine and hematology three years ago and came to this Laboratory in order to devote his entire time to research, on 15 May received a Gold Medal for Scientific Achievement at NRDL's third annual presentation ceremony. A Silver Medal was presented to Dr. William C. Schieve, a physicist in the Nucleonics Division.

The Scientific Director, Dr. E. P. Cooper, made the presentations. In the absence of Dr. Tyan, who was at the world-renowned Karolinska Institute in Stockholm, Sweden, until September under a one-year NRDL-sponsored Fellowship, the Gold Medal was accepted by the Head of the Experimental Pathology Branch, Mr. Leonard J. Cole.

The award was made for Dr. Tyan's "original observations, development of experimental techniques, and formulation of hypotheses concerning the immunological mechanism and process by which the living animal rejects genetically foreign tissues or cell transplants." Dr. Tyan has shown that the mammalian immune system is heterogeneous in function, i.e., that the cell system, or "line" of cells in mice which responds to xeno-geneic (i.e., rat) skin grafts is qualitatively distinct from the cell population which responds to an allogeneic (i.e., from another strain of mouse) skin graft. Furthermore, these cell "lines" appear to possess dissimilar biological properties, as seen by their responses to X radiation, to passively transferred specific antisera, and to their relative dependence on the thymus."

Dr. Schieve's award was for "development of basic theoretical physics methods, and through their application clarifying previous work and extending the modern theory of thermal conductivity in solids."

DR. SCHIEVE ALSO RECEIVES NRDL FELLOWSHIP

In September 1964 Dr. Schieve, recipient of a NRDL Fellowship, went to the Free University of Brussels for one year. He will work with Professor I. Prigogine, Head of the Statistical Physics Group, the foremost group in the world studying non-equilibrium statistical mechanics.

3RD GOLD MEDAL WINNER -- Dr. Marvin Lee Tyan, recipient of a Gold Medal for Scientific Achievement in 1964 was in Sweden at the time the ceremony was held.



WIFE SHARES HAPPY MOMENT -- Dr. William C. Schieve and his wife, Florence, display the Silver Medal presented to him.

SUPERIOR CIVILIAN -- Albert L. Smith receives Superior Civilian Service Award from CAPT D.C. Campbell, Commanding Officer and Director.



DR. LEONG IN EUROPE ON NSF FELLOWSHIP

In April 1964 Dr. George Leong, Head of the Cellular Radiobiology Branch, went to the Universite Libre de Bruxelles, Brussels, Belgium on a one-year Fellowship from the National Science Foundation. He will work with the Director of the Morphologie Animale, Professor Jean Brachet, who is recognized universally as an authority in experimental cell biology.

COMMENDATION MEDAL TO LT. COL. VUILLEMOT

A Navy Commendation Medal was presented to Lt. Col. Floyd Vuillemot, USMC, former Marine Corps Liaison Officer at NRDL, at a special ceremony on 23 December. (He was then attached to the Marine Barracks, Treasure Island, pending retirement on 31 December.) The citation stated in part: "For meritorious achievement in the performance of his duties while serving at the U. S. Naval Radiological Defense Laboratory from 1 July 1962 to 31 October 1963...During this period he conceived the idea of utilizing special aerial reconnaissance techniques for the detection and evaluation of the consequences of nuclear explosions. As the first Project Officer of Project ARNE (Aerial Reconnaissance of Nuclear Explosions) he pushed for and obtained sufficient field evaluation to indicate the potential military worth of this technique...this concept was sold and started on its way to being a major research and development effort with high military operational potential."

DR. BORG SELECTS NRDL FOR RESEARCH

Dr. Alfred F. Borg, Professor and Head, Department of Bacteriology at Kansas State University, did research at NRDL two days a week from March through May with Dr. R.K. Main, Experimental Pathology Branch. On a year's sabbatical leave starting in September 1963 under a NSF Science Faculty Fellowship, Dr. Borg took classes at the University of California and the last three months of his leave, worked at Scripps Institution of Oceanography.

VIENNESE COMES UNDER DEFENSE SCIENTIST IMMIGRATION PROGRAM

Dr. Bruno M. Kalab, a physicist from Vienna, Austria, came to NRDL in May, the first person to be hired at a Department of Defense Laboratory in the Bay Area under the Defense Scientist Immigration Program (DEFSIP). All arrangements were made through the DEFSIP office in Frankfurt, Germany.

REWARDED FOR WORK ON TRIESTE

Based on the excellent "crash basis" manner in which they prepared instrumentation for use in the nuclear submarine Thresher search effort in Spring 1963, 18 members of the Radiation Electronics Branch in April shared a \$300 Group Superior Achievement Award. The following month an additional \$200 Superior Group Award was forwarded from the Chief of the Bureau of Ships for five NRDLers -- Messrs. K. A. Miller, H. A. Zagorites, E. J. Wesley, L. A. Perrine, and D. H. Williams.

DR. PLAYFAIR GETS CANCER SOCIETY GRANT

Dr. John Playfair, NRDL's 7th Scientist-in-Residence, completed his stay. However, before returning to London to his position at the Royal Marsen Hospital in the Clinical Research Department, he will research at the University of California for from six to 12 months on a grant from the American Cancer Society. He will work with Dr. B. Papermaster, new Assistant Professor in the Microbiology Department, on the study of antibody formation. In addition, Dr. Playfair will work at NRDL two days a week to complete the research he was doing in the Experimental Pathology Branch on bone marrow transplantation and the study of immune responses.

OTHER 1963 SCIENTISTS-IN-RESIDENCE REMAIN

The other two Scientists-in-Residence who came to NRDL during 1963 chose to become permanent employees here at the end of their one-year appointments. Dr. Walter Weyzen, an M.D. from Leyden University, Netherlands, will continue the work that he was doing in Bio-Med's Microbiology and Immunology Branch. He has been investigating allotypes of serum proteins in inbred strains of mice by means of different immunoelectrophoresis techniques. Mr. Wolfe Mostow, an Operations Research Analyst from the Institute of Naval Studies, Cambridge, Mass., who had been working in the Military Evaluations Division, moved to the Operational Requirements Office. He will participate in the review and formulation of guidance for formal operational requirements relative to the Laboratory's mission, with prime emphasis on Naval requirements.

1964 ARRIVALS

Three more Scientists-in-Residence arrived at NRDL during 1964, bringing the total to 10 since the Program was approved by the Civil Service Commission in 1960. They are pictured on page 42. This Program brings to the Laboratory, usually for one year, scientists who have

SCIENTISTS - IN - RESIDENCE

DR. JOHN DAVIDSON, Associate Professor of Theoretical Physics, Rensselaer Polytechnic Institute, Troy, N. Y., joined the Nuclear Radiation Physics Branch. He continued his investigations of nuclear structure of even-even nuclei in the rare earth and transuranic regions of the periodic table.



MR. ÅKE A. SVANHEDEN, University of Uppsala (Sweden), where he is in charge of the synchrocyclotron of the Gustaf Werner Institute, is working on the NRDL cyclotron. In 1955 he extracted the proton beam from the Uppsala synchrocyclotron using the non-linear regenerative method.



MR. RAYMOND SCHOFIELD of the Christie Hospital and Holt Radium Institute in Manchester, England, joined the Experimental Pathology Branch. He is a research specialist on calcium metabolism in cells, radiation protection in primates, and red blood production control.



achieved distinction in their fields and who can be expected to contribute new ideas and techniques. The scientist-in-residence is free to perform research of his choice in the Laboratory's sphere of interest and is expected to be available for consultation and participation in the NRDL seminar program.

GENERAL AWARDS

Nineteen Superior Accomplishment Cash Awards totaling \$3,370 were presented to 31 civilians (5 of the total were group awards). Fourteen people received Outstanding Performance ratings for the year; and 35 were granted a Quality-Step-Increase.

Ninety-one Beneficial Suggestions were received and 18 of them were adopted with a total cash award of \$715. Four Patent Awards totaled \$700.

The Laboratory received the Secretary of the Navy Award for Achievement in Safety and two Safe Driving pins were earned.

Seven civilians completed their career at NRDL and each was presented an attractive retirement pin.

OTHER HONORS

Dr. William E. Kreger, Head, Nucleonics Division, was elected Chairman of the Shielding Division of the American Nuclear Society (ANS). He will serve for one year starting June 1964. The Shielding Division is one of six professional divisions of ANS which has over 6,000 national members.

Dr. Myron S. Silverman, Head, Microbiology and Immunology Branch, was selected as a Diplomat of the American Board of Microbiology.

The Army's 5th highest award, the Legion of Merit, was presented to Lt. Col. James S. Dearth, USA (Ret.), the last week in December. Mr. Dearth became a civilian Operations Research Analyst at NRDL in August, shortly after he retired from the Army after more than 23 years of service. The award was based on his exceptionally meritorious conduct in the performance of outstanding services while serving as Deputy Chemical Officer and Chief of the Nuclear Branch, Nuclear and Chemical Biological, and Radiological Division, Office of the Deputy Chief of Staff for Operations, Plans and Training, Headquarters, Sixth U. S. Army from June 1960 to July 1964.

The Alameda County Rehabilitation Center (County Prison Farm) at Camp Parks continued to perform a number of services for NRDL which immeasurably contributed to the program of projects at the field facility. On 4 September several members of the Laboratory's staff paid a visit to Santa Rita to present an award of thanks and certificates of appreciation to Sheriff F. T. Madigan, Chief J. D. Dignan, Captain K. L. Mitchell, Sgt. L. M. Santucci, and Deputy R. L. Ferguson.

Dr. E. L. Alpen, Head, Bio Med Division, has been appointed by OP-NAV as the Navy representative to assist DASA project officers with projects in conjunction with biomedical aspects of ionizing radiation. Also, on Navy recommendation, K. Kaulum, Chem Tech Division, was appointed by DASA to replace R. Soule, Chem Tech, as Assistant Technical Director for Radiation for Operation SPINDRIFT.

Dr. B. Dunicz, Physical Chemistry Branch, was elected a Fellow of the AAAS.

Before Peter O. Strom, Jr. returned from the University of Oslo, Norway, in June where he attended college for one year under NRDL sponsorship, Professor Alexis C. Pappas, one of the world's leading nuclear chemists wrote: "Mr. Strom has passed his exams (for) his cand. real... which in his case is equivalent to your Ph.D...Peter is one of the most able young scientists I have met..."

CHAPTER V

SEMINARS -- SYMPOSIA -- CONFERENCES

MANAGEMENT DEVELOPMENT PROGRAM

The Management Development Program started in 1963 by CAPT D. C. Campbell, Commanding Officer and Director, continued at an accelerated pace in 1964:

On 15 January, Dr. Alvin M. Weinberg, past member, President's Science Advisory Committee and Director, Oak Ridge National Laboratory, led a provocative discussion on the "Criteria for Scientific Choice." On 29 January, Dr. Edward Wenk, Technical Assistant to the Director, Office of Science and Technology, discussed "Science and Public Policy" and led an informal question and answer session on DOD, National Science Foundation, AEC and ONR project structuring, etc. On 12 March, Dr. Robert O. Burns, Head of the Technical Analysis and Advisory Group, OPNAV, spoke on "The Place of OPNAV in the Navy R&D Picture." On 26 March, RADM J. H. McQuilkin, USN, Assistant Chief of BUSHIPS (R&D), conducted a Management Seminar "Today in Washington." Mr. Linton P. von Beroldingen, Manager, Press Relations, Lockheed Missile and Space Division, led a discussion on "Science and the Fourth Estate" on 28 May. Research and Design Work Study Indoctrination was given 11 members of Laboratory management by Messrs. Carlson and Lewis of the Stanwick Corp. on 11 September. This is part of the BUSHIPS program to extend a program of work study and systems analysis into R&D laboratories. On 8 October, Mr. William Jasper, Head, Test Development and Personnel Research Section of the Pasadena Board of Civil Service Examiners for Scientists and Engineers, presented a summary of his research efforts on performance evaluation with R&D oriented organizations. On 19 October, Dr. Gerald P. Foster, Assistant Professor of Public Administration, University of Denver, discussed the problem of performance evaluation of scientific personnel. On 17 December, Dr. Calvin Taylor, Professor of Psychology at the University of Utah, now on a year's absence with the Naval Personnel Research Activity, San Diego, discussed methods that have been developed by him and his group at Utah for measuring creativity.

A new development in the Management Development Program was the use of locally prepared case studies in research management in unstructured

groups of staff members. These groups meet away from the Laboratory, using the facilities available at Treasure Island, on an overnight basis. These sessions proved to be very stimulating and productive.

OTHER MEETINGS AT NRDL

The DASA Panel on Radiological Instruments held their 24th meeting at NRDL 13-14 January. On 10 February NRDL, in conjunction with ONR, San Francisco, co-hosted a colloquium on "The Hyperbaric Environment." The first conference involving representatives of the U. S. Marine Corps, OPNAV, BUSHIPS, NMC, and NDAL was held at NRDL on 13-16 April to kick off an 18-month study on nuclear, chemical, and biological warfare. On 2-3 April the Subcommittee of Radiation Shielding of the NAS-NRD Advisory Committee on Civil Defense held their 16th meeting here. An Orientation Team from the Army Munitions Commander under direction of Col. N. I. Shapira, CmlC, USA, made a classified presentation on BW-CW to selected NRDL personnel on 25 May. In June, subtask transfer meetings involving the Office of Civil Defense and the Laboratory's Technical Management Office were held. West Coast Navy Laboratory Librarians held a meeting 23-24 July. The 4th Thermal Conductivity Conference was held 13-16 October. Inter-Laboratory Committee on Facilities from Navy laboratories in California held a two day meeting at NRDL early in October.

The annual meeting of the NRDL Sigma Xi convened in the Shipyard's Commissioned Officers' Mess on 25 January. The guest speaker was U.C. Physics Professor Harvey E. White, who discussed plans for the new Lawrence Hall of Science at the University of California, Berkeley. The NRDL Sigma Xi Chapter sponsored the annual open lecture on 24 February with Dr. Lyle B. Borst, Professor of Physics and Astronomy, State University of New York, speaking on "A Diatomic Theory of Liquid Helium." Professor G. Ledyard Stebbins, Chairman of the Department of Genetics, University of California, Davis -- the Sigma Xi Pacific Coast National Lecturer for the academic year 1964 - 65 -- lectured at NRDL on 9 October. His subject was "From Gene to Character in Higher Plants."

As in prior years numerous seminars were held on the Divisional and Branch level to keep investigators informed on latest developments in their specialized areas. While perhaps the majority of these were conducted by NRDLers, scientists from universities and industry were also well represented. Coming from other countries to present seminars were: Dr. E. Gerlach, Physiologisches Institute, Heidelberg, West Germany;

Dr. T. F. Slater, University College Hospital, Medical School, London, England; and Dr. Harry Smith, Microbiological Research Establishment, Porton, England.

MEETINGS ELSEWHERE

CAPT D. C. Campbell, Commanding Officer and Director, was one of a limited number of military commanders invited to attend the 1964 Western States Governors' Conference. He attended many conferences throughout the year, notably the 12ND Open Season Conference; a fallout formation, distribution and effects meeting in Washington (under NRDL sponsorship), to provide a mechanism for exchange of information in the OCD subject area of radiological phenomena and effects; by invitation from the Hon. R. W. Morse, Assistant Secretary of the Navy (R&D), a conference on the subject of obtaining more effective utilization of in-house technical capability for ASP Weapons Systems Development; OIR Seminar on Negotiation; Creativity in Management, sponsored by the San Francisco Federal Personnel Council; and BUSHIPS R&D Council Meeting. CAPT Campbell participated as keynote speaker and discussion leader in the Civil Service Commission Institute and Management of Scientific and Engineering Organizations in Washington.

The Scientific Director and his Associate, Dr. E.P. Cooper and Dr. E. R. Tompkins, also attended a variety of meetings, among them Navy Senior Scientists' Council, 8th Navy Science Symposium, BUSHIPS R&D Council Meeting, and Nuclear Weapons Symposium. Many members of the scientific department were active participants at meetings throughout this country and abroad. Scientific meetings attended in other countries included Congress of the International de Physik Nuclaire, Paris, France; Xth Congress of the International Society of Hematology, Stockholm, Sweden; International Colloquium on Bone Marrow Transplantation, Paris, France; Tripartite Technical Cooperation Program (Biomedical), Toronto, Canada; Radiochemical Symposium, Salzburg, Austria; Tripartite Panel on Thermal Radiation and Fire Effect, Surrey, England; Xth International Symposium on Combustion, Cambridge University in England; and the 3rd Mammalian Cytology and Somatic Cell Genetics Conference at San Juan, Puerto Rico.

VI -- TRAINING

172 staff members attended 66 courses in technical and management subjects during 1964. Various seminar programs within the Laboratory attracted maximum participation.

Three employees continued study in programs leading to the bachelors degree, four others were engaged in advanced degree programs and two in postdoctoral study and research. Mr. E. V. Benton and Mr. R. N. Anderson each started a year in residence at Stanford University in Laboratory-supported doctoral programs. Dr. G. F. Leong and Dr. W. C. Scheive are pursuing postdoctoral programs at the Free University of Brussels in Belgium. (Pages 38-40) Mr. L. D. Miller completed a year in residence at Stanford and is now engaged in thesis research in the Laboratory. Mr. T. H. Jones and Mr. F. H. Young were awarded Master's degrees at San Francisco State College in physics and mathematics, respectively.

NRDL continued to participate in the Army's Personnel Management Conferences for Executives and in the Leadership Laboratory for R&D Supervisors.

Dr. W.E. Kreger attended the Civil Service Commission's Institute for Executives in Scientific Programs and Mr. R. C. Lilly the OIR Institute.

The Co-op Program continued to be phased out. The last Co-op student will graduate in June 1965.

The 1964 Summer Employment Program brought seven faculty members, 28 graduate students and 26 undergraduates to the Laboratory for the summer. The group came from 35 educational institutions throughout the U. S.

An educational program for the 34 enlisted personnel on board continued with each man being given an average of 11 hours of instruction each month. One man was advanced in rate. There were five re-enlistments; and one retirement and one transfer to the Fleet Naval Reserve. There were 30 officers assigned to NRDL. Selected for advancement in rank were seven Navy officers, one Marine Corps and one Army. Six retired. Reserve Officer training included: Training Duty (seven days), two, (two weeks) nine; Research Clerkships (60 days) one, (80 days) one; Naval Reserve Unit visits, two; and Lectures to Reserve Units by NRDL Personnel, three.

VII -- VISITORS

Of the 9,838 people who visited this Laboratory during 1964, approximately one-third or 3,045 were professional personnel. The others included San Francisco Naval Shipyard services, 761; outside sales and services, 3,976; interviews or personal guests, 869; and tours, 1,187. CAPT Campbell established a policy of allowing one science student group per month to tour the Laboratory. In addition a number of professional and military groups (including 135 midshipmen making their summer cruise) came aboard.

The Honorable Robert W. Morse, who on 1 July became the Assistant Secretary of the Navy for Research and Development, visited on 7 August. Accompanied by RADM C. T. Booth, USN, Deputy Chief of Naval Operations for Development, and Dr. Howard White, Jr., Special Assistant for Research to the ASTSECNAV (R&D), Dr. Morse had an opportunity to meet all officers, division and branch heads. He was given a briefing on the general organization program and facilities. He also visited the various Laboratory facilities, including the new Cyclotron Building.

The first official visit to NRDL by the new Commandant of the 12th Naval District, RADM J. McN. Taylor, USN, was paid on 18 August. Among the many other distinguished visitors throughout the year were the Assistant to the Secretary of Defense (Atomic Energy), The Honorable W.J. Howard, and members of his Sec Def Ad Hoc Group; RADM W. F. Petrovic, USN, Assistant Chief of the Bureau of Ships for Field Activities and Inspector General; RADM Cecil Riggs, MC, USN, Assistant Chief of the Bureau of Medicine for Planning and Logistics and BuMed Inspector General; RADM F. T. Williamson, USN, Commander, Training Forces, Pacific; members of the U.S. House of Representatives Subcommittee on Oceanography of the Merchant Marine and Fisheries Committee -- including Representatives T. L. Ashley and C. A. Vanik (both Dem., Ohio); Mr. Frank Sanders, Staff Assistant, the Military Construction Subcommittee of the House Appropriations Committee; Lt. General H. C. Donnelly, USAF, new Director of the Defense Atomic Support Agency; Col. I. J. Russell, USAF, AFWL, Kirtland AFB; Brig. General Crawford Sams (MC) USA (Ret.), now with UC Medical School; Dr. Frank Shelton, Prospective Chief Scientist, DASA; Dr. John H. Huth, Chief Scientist, BUSHIPS; Col. Howard C. Rose, USAF, Chief, Radiation Division, DASA; Mr. Ted George, ARPA Cloudgap Program.

One of three Americans sharing the 1958 Nobel prize for Medicine and Physiology, Professor Joshua Lederberg of Stanford, was a visitor, as well as RADM W. Welham, USN, Assistant Chief of BuMed for Research and Military Medical Specialties; Dr. Alexander L. Slafkosky, Scientific Advisor, DCS/R&D, Headquarters, USMC; Col. C. L. Hanson, USAF, AFRRI; Dr. Roger Preston (first Officer-in-Charge at NRDL, 1947), Lawrence Radiation Laboratory; Mr. W. E. Strobe (NRDLer 1948-61), Assistant Director of Civil Defense for Research; Col. J. W. Crosby, USAF, National Military Command Systems Support Center; Mr. John F. Stearns, Chief, National Reference Center for Science and Technology, Library of Congress; Brig. Gen. R. M. Nellis, (VC) USA, Office, Army Surgeon General, accompanied by Col. J. P. Crawford, (VC) USA, Sixth Army Headquarters; Col. D. H. Behrens, MC, USA, AFRRI; Dr. M. R. Billings, Joint Command and Control Requirements Group, JCS; Dr. L. D. P. King and Dr. Wendell A. Biggers, LASL and Messrs. G.P. Dix and R. S. Decker, Space Nuclear Propulsion Office.

Visiting scientists from other countries included Dr. Jacques Le Maignen, Director of Research Nuclear Division, Thompson-Houston Cie, Paris, FRANCE; Dr. L.H. Gray, Fellow, Royal Society and Director, The Radiobiology Research Unit, Mt. Vernon Hospital, and Radium Institute, Northwood, ENGLAND; Dr. H. Pauly, Max Planck Institute for Biophysics, Frankfurt, WEST GERMANY (at present visiting professor at the University of Pennsylvania); Dr. J. Ginner, Syntex, S.A., MEXICO; Dr. I. Schmidtko, Medizinische Universitätsklinik, Freiburg, WEST GERMANY; Dr. C. Asiddao, University of PHILIPPINES; Dr. Otar Chakohava of the Gamalaya Institute, MOSCOW, USSR; several members of the FRENCH Atomic Energy Commission; and Mr. W. T. L. Neal, BRITISH Ministry of Agriculture, Fisheries and Food.

Foreign military dignitaries included Sir Alfred Sims, Director-General Ships, ADMIRALTY; Chief of Naval Operations of ARGENTINA, RADM B. I. Varela; RADM C. G. Arguelles, ARGENTINA Naval Attache, Washington, D.C.; Director of the PERUVIAN Naval War College, RADM Luis Rivero; Director of the ARGENTINA National War College, RADM R. O. Estevarena, and 41 students; two groups of NATO officers, representing Belgium, Canada, Denmark, England, France, Germany, Greece, Italy, Netherlands, Norway, and Turkey; Senior FRIENDLY ALLIED Naval Officers, part of the U. S. Government's People-to-People Program (similar groups were here in 1960, 1962, and 1963); and CDR Ralph von Gregory, MC, GFN, Deputy Surgeon-General, FEDERAL GERMAN Navy.



ASST SECNAV (R&D) VISITS NRDL -- Dr. R. W. Morse, Assistant Secretary of the Navy (R&D) listens to CAPT D.C. Campbell, Commanding Officer and Director, explain about a Laboratory field project. At right is Dr. E.R. Tompkins, Associate Scientific Director. Dr. Morse was here on 7 August 1964.



VISIT BY NEW COMMANDANT -- RADM John Taylor, 12ND Commandant, on his first official visit to NRDL on 18 August 1964 greeted all of the officers. Here he is shown shaking hands with LT Audrey Gray, Security Officer.

CHAPTER VIII -- PUBLICITY

Arrangements were made with producers of the Navy Research and Development (NARAD) Briefing Film Report to submit film sequences showing the various stages to final construction of the NRDL 70" cyclotron and covering the installation of the cyclotron magnet and coil assembly.

UNDERSEA TECHNOLOGY, April 1964, carried a two-page spread about NRDL. BUSHIPS JOURNAL carried two articles -- March 1964, "Nickel Cadmium Rechargeable Cells," by R. L. Hopton, Radiation Electronics Branch; and May 1964, "15,000 Curie Cobalt-60 Range at USNRDL."

The radiation source "hang-up" incident at the Camp Parks Cobalt-60 Range hit the 31 May edition of the San Francisco Chronicle. A factual account of the situation and of the award (see page 37) was given with emphasis to the effect that there was absolutely no danger to the general public.

Scientific achievements of NRDLers were well covered by Bay Area and hometown papers as well as the wire services and journals. The July-September edition of the U.S. Civil Service Journal devoted a full page to the NRDL Scientists-in-Residence Program. OIR Newsletter for April 1964 carried the story of Dr. George Leong's Fellowship to Brussels.

Dr. R. W. Brauer participated on the Owen-Spann Show on radio station KGO upon his return from Peru. He related experiences of his 2½ month expedition, preparatory to setting up a long-range aging process study in that country.

NRDLers on the whole are a civic-minded group and take an active part after-hours in civic, school, and church affairs, including giving frequent lectures.

IX -- MISCELLANEOUS

OPEN HOUSE -- The Laboratory's observation of Navy Day and Navy Week took the form of an informal open house on 24 October for the Laboratory employees' immediate families.

MINORITY GROUP RELATIONS -- NRDL did not participate in any formal manner in any of the local community relations programs during 1964. However, in October, Mr. Walter G. Hooke, Project Director, Skills Bank of the Urban League, visited the Laboratory to see the facility and to discuss with Laboratory management the utilization of minority group personnel.

MOST SUCCESSFUL UNITED CRUSADE -- While not reaching its goal, the 1964 NRDL United Bay Area Crusade was far more successful than any previous year with participation slightly in excess of 90 percent. NRDL was included with other activities in the San Francisco area in receiving a "hearty well done" from COM 12.

KENNEDY MEMORIAL -- Contributions to the John F. Kennedy Memorial Library fund from NRDL personnel started off at slightly above \$200 and was nearing the \$300 mark at the end of the year. Some 112 lab personnel had participated to date.

WOMAN OF THE YEAR -- Audrey Shake, San Francisco Naval Shipyard Purchasing Agent and NRDL Buyer, was named "Woman of the Year" by the Women Supervisors of SFNS at their annual "Woman of the Year and Bosses Night" held on 24 January.

218 GET CHEST X-RAYS -- 218 of the 541 civilians at NRDL or 40% participated in the Voluntary Chest X-Ray Program when the mobile unit was here on 30 October.

AIR POLLUTION SURVEY -- Approximately 340 NRDLers took kits on 20 May in order to participate in the project on the effects of air pollution in man being conducted by U.C.'s Research Cytology Laboratory.

FLEAMARKET REPLENISHES FUNDS -- A Fleamarket Sale held at the Laboratory on 18-19 November added \$126 to the Welfare and Recreation funds. The Wel & Rec sponsored the annual picnic on Saturday, 3 October; and Christmas party on 12 December; also, tournaments for golf, bowling, bridge, fishing, and tennis. A Flying Club was formed at NRDL during the year.